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Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant:

DAVID LOUGHNAN

Invention Title:

MECHANICAL COUPLING

The invention is described in the following statement:

MECHANICAL COUPLING

The present invention relates to a mechanical coupling and, more specifically, to a mechanical coupling for coupling a motor to an intermediate portion of a shaft in order to enable the motor to drive the shaft, while allowing the motor to be decoupled from the shaft by application of a predetermined torque to the shaft. The invention is particularly, although not exclusively, directed to coupling a motor for automatically steering a vehicle to a steering shaft of the vehicle while allowing decoupling of the motor and the shaft by application of a torque to the shaft by an operator operating a steering wheel attached to the shaft.

Automatic steering systems in which the steering of a vehicle is operated by a computer controlled motor are well known in agricultural vehicles, such as tractors, and are likely to become common in passenger vehicles as the technology develops. An important safety consideration of such systems is that an operator should be able to quickly and easily manually override the automatic steering system. Typically, a separate control is provided, such as a switch, which can be used by an operator to override the automatic steering system. However, it is more desirable to allow an operator to override the automatic steering system merely by operation of the normal steering controls of the vehicle. Although several systems have been proposed, including systems which electronically detect torque applied to the steering wheel and operate a control system to decouple the motor from the steering system, there appears to be a need for a safe and simple automatic override system for use with vehicles in which a steering wheel is connected to ground

engaging wheels via a steering shaft and a power steering system.

According to the present invention, there is provided a mechanical coupling for coupling a rotatable driving element to a shaft, wherein the mechanical coupling includes:

a link for connecting the driving element to a secondary driving element which is coaxial with the shaft;

a clutch mechanism, mechanically between the secondary driving element and the shaft; and

wherein the clutch mechanism is adjustable so that in use the driving element can drive the shaft substantially without slippage, but so that a torque applied to said shaft, other than via the clutch, in order to override the action of the driving element, causes the clutch mechanism to slip, thereby overriding said driving element and allowing the shaft to be driven by the overriding torque, without said overriding torque being applied to the secondary driving element.

Preferably, the clutch mechanism is configured around the shaft.

Preferably, the driving element is connected to the shaft via a gear mechanism.

Preferably, the link includes said gear mechanism.

Preferably, the clutch mechanism is mechanically between the gear mechanism and the shaft.

Preferably, the clutch mechanism is operated by a fluid controlled system.

Preferably, the fluid controlled system is regulated by a computer which thereby controls adjustment of the clutch.

Preferably, the fluid controlled system includes

a fluid chamber.

Preferably, the fluid chamber is configured around the shaft.

Preferably, the secondary driving element is configured around the shaft.

Preferably, there is provided a connection element which extends between the fluid chamber and the clutch mechanism in order to operate the clutch mechanism.

Preferably, the connection element is configured around the shaft.

Preferably, the shaft is a steering shaft of a vehicle.

Preferably, the torque applied to the shaft other than via the clutch mechanism is applied manually via a steering wheel or other steering element.

The fluid controlled system may be operated from a pump used for the power steering system of the vehicle.

Preferably the driving element is the output of an automatic steering system.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is an axial cross-section along a portion of a steering shaft showing the configuration of a preferred embodiment of a mechanical coupling in accordance with the present invention, in a state corresponding to an automatically driven motor being coupled to the steering shaft;

Figure 2 shows the embodiment of Figure 1 in a state where the automatically driven motor is not mechanically coupled to the steering shaft; and

Figure 3 shows schematically the provision of the embodiment of Figures 1 and 2 in a steering system of a

vehicle.

With reference to Figures 1 and 2, a preferred embodiment of a mechanical coupling in accordance with the present invention will now be described.

A mechanical coupling generally designated 10 provides a coupling between a shaft in the form of a steering shaft 1 and a rotatable driving element in the form of an output shaft 5 from an automatically driven motor (not shown in Figures 1 and 2) of an automated steering control system. The output shaft 5 of the automatically driven motor is connected to a link in the form of a worm gear mechanism 12 in order to convert the rotary motion of the output shaft 5, which is not coaxial with the steering shaft 1, into rotary motion of a secondary driving element in the form of a generally cylindrical sleeve 14 which is coaxial with the steering shaft 1. The worm gear 12 may also be geared to provide a desired gear ratio between the input shaft 5 and the sleeve 14. The generally cylindrical sleeve 14 extends around but is not directly rotationally coupled to, the steering shaft 1. The generally cylindrical sleeve 14 is rigidly coupled to a clutch housing 16 which is generally cylindrical and which rotates with the generally cylindrical sleeve 14. The clutch housing extends around, but is not directly rotationally coupled to, the steering shaft 1. The clutch housing includes a drive face 18 on an inner surface thereof which extends generally radially with respect to the steering shaft 1. Located partially within the clutch housing 16, there is provided a connection element 20 which includes a flange portion 22 and a generally cylindrical shaft portion 24. The connection element includes a cavity therein through which the steering shaft 1 passes. The flange portion 22 of the

connection element 20 extends from a first end 20a of the connection element 20 generally radially away from the steering shaft 1. The flange portion 22 is entirely contained inside the clutch housing 16 and includes a contact face 22a which generally faces the drive face 18. The generally cylindrical shaft portion 24 of the connection element 20 extends along the steering shaft 1, away from the worm gear 12, and extends for some distance before terminating at a second end 20b of the connection element 20.

The clutch housing 16 further contains a generally annular clutch plate 26 which lies between the drive face 18 of the clutch housing 16 and the contact face 22a of the flange portion 22 of the connection element 20. As can be seen in Figure 1, when the clutch plate 26 is in firm contact with both the drive face 18 and the contact face 22a, these elements together constitute a clutch mechanism 17 in an engaged state.

The clutch mechanism 17 is operable by an operating cylinder 28 which is operated by fluid pressure resulting from regulated input of a fluid (typically hydraulic fluid for a hydraulic system or air for a pneumatic system) through a fluid inlet 30 provided in the operating cylinder 28. Provided in the operating cylinder is an operating piston 32 which includes a flange portion 32a which extends radially away from the drive shaft 1 and the distal periphery of which seals against the casing of the operating cylinder 28. The operating piston 32 further includes a generally cylindrical portion 32b, which extends to either side of the flange portion 32a. The cylindrical portion 32b of the operating piston 32 includes a cylindrical bore therethrough, through which the steering shaft 1 and the generally cylindrical shaft

portion 24 of the connection element 20 extend. The cylindrical portion 32b of the operating piston 32 is sealed against the generally cylindrical shaft portion 24 of the connection element 20 by seals (not shown).

The operating cylinder 28 contains a helical spring 34 which provides a bias force to bias the operating piston 32 away from the clutch housing 16. The helical spring 34 is provided between the flange portion 32a of the operating piston 32 and a first end 28a of the operating cylinder 28. The first end 28a of the operating cylinder 28 corresponds to the end of the operating cylinder which is closer to the clutch housing 16 and worm gear 12. Between the flange portion 32a of the operating piston 32 and a second end 28b of the operating cylinder, is provided a fluid chamber 36 into which fluid from the fluid inlet 30 may be forced.

Increase in fluid pressure in the fluid chamber 36 forces the operating piston against the bias force of the helical spring 34 and towards the first end 28a of the operating cylinder 28.

Attached to the second end 20b of the connection element 20, there is provided a pair of castellated nuts 38 which, when the fluid pressure in the fluid chamber 36 is relatively high (as shown in Figure 1), may be borne upon by the outside of the second end 28b of the operating cylinder 28. A thrust washer (not shown) is preferably provided between the castellated nuts 38 and the second end 28b of the operating cylinder 28. The castellated nuts 38 extend around the circular circumference of the second end 20b of the connection element 20, so that both the second end 20b of the connection element 20 and also part of the steering shaft 1 pass through the castellated nuts 38. Rotationally coupled to the second end 20b of

the connection element 20, there is provided one unit 40 of a two-unit flexible drive mechanism. The other unit of the flexible drive mechanism (not shown) is rigidly attached to the steering shaft 1. It should be noted that the flexible drive is the only point at which the mechanical coupling 10 is rotationally coupled to the steering shaft 1. It will be appreciated by those skilled in the art that in order to support the mechanical coupling 10 on the steering shaft 1 and also in order to support, for example, the clutch housing 16 on the connection member 20, and the operating piston 32 on the generally cylindrical shaft portion 24 of the connection element 20 and (whilst maintaining the integrity of the chamber 36) various bearings or seals may be required. For simplicity, these are not shown in the drawings but provision of such elements could be accomplished by the person skilled in the art without exercise of inventive faculty.

Figure 1 represents a first state of the mechanical coupling 10, in which the clutch mechanism 17 (formed by the contact face 22a of the flange portion 22, the clutch plate 26 and the drive face 18 of the clutch housing 16) is engaged. It should be appreciated that any appropriate form of clutch mechanism could be used and a fluid filled clutch mechanism may be desirable in order to reduce wear on the elements thereof. The engagement of the clutch mechanism is controlled by the application of fluid pressure in the chamber 36.

When there is negligible fluid pressure in the chamber 36, or at least insufficient fluid pressure to overcome the bias force provided on the operating piston 32 by the helical spring 34, the mechanical coupling will be in the second state, illustrated in Figure 2, that is,

the operating piston 32 will not extend far out of the first end 28a of the operating cylinder 28. Consequently, the castellated nuts 38 and the clutch housing 16 will not be forced away from each other, so that the drive face 18 of the clutch housing 16 and the clutch plate 26 will not be forced against the contact face 22a of the flange portion 22. In this second state, as illustrated in Figure 2, when the generally cylindrical sleeve 14 which forms the output from the worm gear 12 rotates, also causing the clutch housing 16 to rotate, this rotation will not be transmitted via the clutch mechanism to the connection portion 20 and thus will not be transmitted to the steering shaft 1.

When adequate fluid pressure is applied in the chamber 36, the operating piston 32 is forced towards the first end 28a of the operating cylinder 28, against the bias force of the helical spring 34. The cylindrical portion 32b of the operating piston 32 therefore extends a significant distance past the first end 28a of the operating cylinder 28 until an end portion thereof abuts and is forced against the clutch housing 16 forcing the drive face 18 and the clutch plate 26 against the contact face 22a of the flange portion 22 of the connection element 20 (that is, the drive face 18 and clutch plate 26 are forced to the left, as seen in Figure 1, relative to the contact face 22a). The flange portion 22 is not free to move away from the clutch plate 26 (to the left as shown in Figure 1) because the second end 28b of the operating cylinder 28 abuts the castellated nuts 38 applying a force directed away from the worm gear 12 (that is, to the right as shown in Figure 1) which also provides a force on the flange portion 22 away from the worm gear 12 and towards the clutch plate 26. Thus, when there is

sufficient fluid pressure in the fluid chamber 36, the clutch is engaged and the rotation of the worm gear 12 and the clutch housing 16 is transmitted through the clutch plate 26 to the flange portion 22 and through the connection element 20 and flexible drive unit 40 to the steering shaft 1.

Thus, the fluid pressure dictates whether the clutch is engaged or not and consequently whether the worm gear, and attached automatic steering system, is mechanically coupled to the steering shaft 1. It should be appreciated that the distances moved by the various parts are exaggerated in Figures 1 and 2 in order to clearly illustrate operation of the coupling. In a preferred embodiment, movement of the contact face 22 of only a fraction of a millimeter may be sufficient to engage or disengage the clutch mechanism.

The amount of fluid pressure applied to the chamber 36 is of critical importance to the functioning of the mechanical coupling 10. In the preferred embodiment, it is intended that an operator of the vehicle, such as a small tractor, into which the automatic steering system and mechanical coupling 10 have been installed should be able to quickly, easily and intuitively override the automatic steering system merely by turning the steering wheel of the vehicle. This is achieved by setting the pressure of fluid in the operating cylinder 28 to a level at which the torque applied by the automatic steering system via the worm gear 12 will not cause the clutch mechanism to slip, but the torque applied by a person operating the vehicle will be sufficient to cause the clutch to slip. Crucially, because the vehicle has a power steering system, the torque applied by the automatic motor via the worm gear 12 need be only small. For

example, torque of about 3in lbs, about 0.3Nm, may be adequate to drive the steering shaft 1. Clearly, with the clutch mechanism set so that there is no clutch slippage at 0.3Nm, but so that slippage will occur at, for example, an applied torque of between 0.6 and 1.0Nm, the connection of the worm gear 12 to the steering shaft 1 can be easily intuitively and immediately overcome by an operator turning the steering wheel of the vehicle. Thus, with the fluid pressure correctly maintained to give the desired slip characteristics for the clutch mechanism 17, it can be seen that the described embodiment provides a mechanical coupling for an automatically driven motor to operate a drive shaft 1 whilst allowing quick, simple and intuitive override by an operator.

The fluid pressure in the fluid chamber 36 required to maintain such a light setting of the clutch mechanism 17, is relatively small. In a preferred embodiment, the clutch mechanism is operated hydraulically and needs only approximately 20lbs per square inch or about 140 kPa fluid pressure. Again, in the preferred embodiment, the worm gear 12 gives a gearing of 10 to 1, and as previously discussed the torque required to turn the steering shaft 1 is low, so a hydraulic motor can effectively operate the steering system using a fluid pressure of approximately 200lbs per square inch (i.e. about 1,400 kPa). A typical power steering system for a tractor might use fifteen times this fluid pressure and it is thus possible, and desirable, to use the hydraulic pump of the power steering system of the vehicle to drive the motor which moves the steering shaft 1 and to provide the fluid pressure required to keep the clutch mechanism 17 lightly engaged. This may use sufficiently little of the power steering system's capacity to have a negligible or

tolerably small effect on the power steering system. It is preferred that a pressure reducing valve be used for operation of the hydraulic motor of the automatic steering system to moderate the amount of hydraulic fluid required, and providing pressure reduction in this way also prevents the hydraulic motor from acting too aggressively upon the steering shaft 1.

Referring now to Figure 3, typically, a computer 70 is used for automatic steering of a vehicle, and in a preferred embodiment a differential GPS (global positioning satellite) system is used. Using differential GPS to automatically steer vehicles is known *per se* and will not be described herein in detail. The system, including the computer 70 which provides the automatic steering input, preferably provides three computer outputs 71, 72, 73. The first and second computer outputs 71, 72 control first and second pumps 74, 75 corresponding to first and second directions of operation for a hydraulic motor 76 to operate the motor output shaft 5 which leads to the worm gear 12. The third computer output 73 controls a solenoid pump 77 for pumping hydraulic fluid into the cylinder inlet 30 of the operating cylinder 28 to maintain the clutch in its lightly weighted condition. The hydraulic fluid is supplied to the first and second pumps 74, 75 and to the solenoid pump 77 at ample pressure by a powerful hydraulic pump 78 which supplies a power steering system 79 of the vehicle. Thus the computer 70, in addition to controlling the steering of the vehicle, controls the fluid pressure which operates the clutch mechanism, thereby ensuring that easy and convenient manual override is always available.

Of course, safety is a major consideration and it will be appreciated that the described embodiment will

default to a position in which the clutch is not engaged if there is a lack of hydraulic fluid in the chamber 36.

The chamber 36 or system suppling hydraulic fluid to the chamber 36 may include an additional pressure sensitive safety system (such as a bypass valve) in order to prevent the fluid pressure in the chamber 36 from increasing to a level where the clutch would not slip if manual override of the steering shaft were attempted. As an alternative or additional emergency system, the flexible drive may include a friction clutch, adjusted to allow slippage between the connection element 20 and the steering shaft 1 at a manually attainable torque, but a torque which is distinctly higher than that required to cause slippage of the clutch mechanism 17. In preferred embodiments such a friction clutch is for emergency use only since its characteristics make it unsuitable for use as the normal override mechanism.

In the present embodiment, it can be seen that when the clutch is disengaged (and therefore when manual override of the steering shaft is achieved) the only elements of the mechanical coupling 10 which must be rotated by the operator along with the steering shaft 1 are the flexible coupling 40, the castellated nuts 38 and the connection element 20. Clearly, this provides a considerable benefit in ease of handling the steering system over, for example, providing the clutch mechanism between the worm gear 12 and the motor 76, since the relatively cumbersome (and possibly adversely geared) worm gear 12 need not be manually operated.

It will also be noted that the described embodiment is compact and co-axial with the steering shaft, and will thus not require significant additional space. Furthermore, the described embodiment may be

connected to the steering shaft without substantially disturbing the normal geometry of the steering system of the vehicle. Complex fitting to the steering shaft is not required since the mechanical coupling is simply slid over the steering shaft and connected thereto at the flexible drive.

Of course, it will be appreciated that many modifications and variations of the described embodiments are envisaged which will not be fall outside the scope of the present invention. For example: the type of clutch or mechanism by which the clutch is operated may be different; systems for operating the clutch other than hydraulic systems may be used, for example, pneumatic systems; biasing of the clutch to its disengaged position may be accomplished by means other than the helical spring 34, and so forth. Also the mechanical coupling is not limited in use to coupling a steering shaft to an output of an automatic steering system, but has utility in other areas where it is desired to provide quick and convenient override of a driven shaft.

Throughout this specification and the claims, the words "comprise", "comprises" and "comprising" are used in a non-exclusive sense, except where the context requires otherwise.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or in any other country.

Modifications and improvements may be incorporated without departing from the scope of the present invention.

Dated this 9th day of July 2002

<u>DAVID LOUGHNAN</u>

By his Patent Attorneys

GRIFFITH HACK

Fellows Institute of Patent and Trade Mark Attorneys of Australia

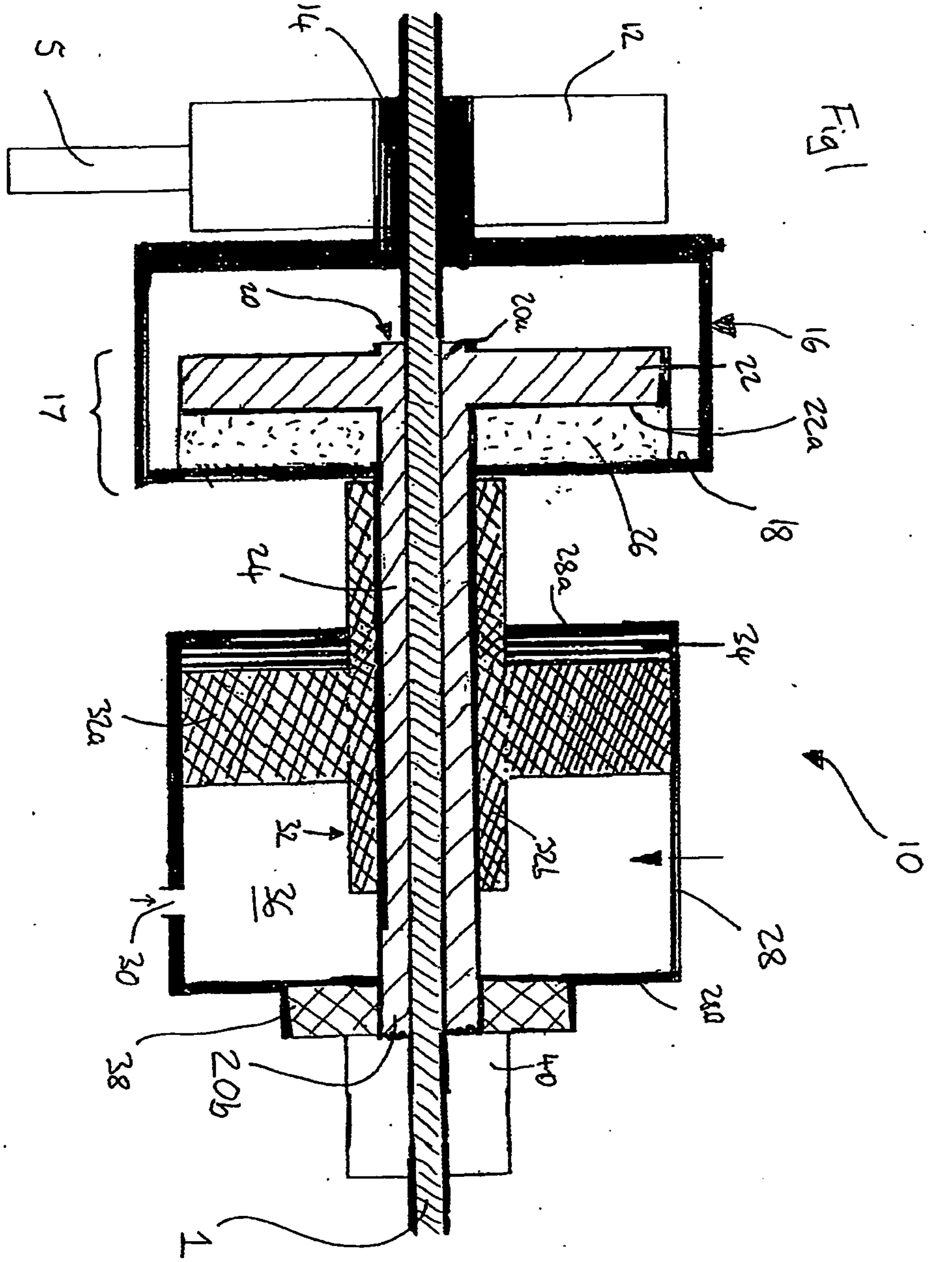
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Fig 1

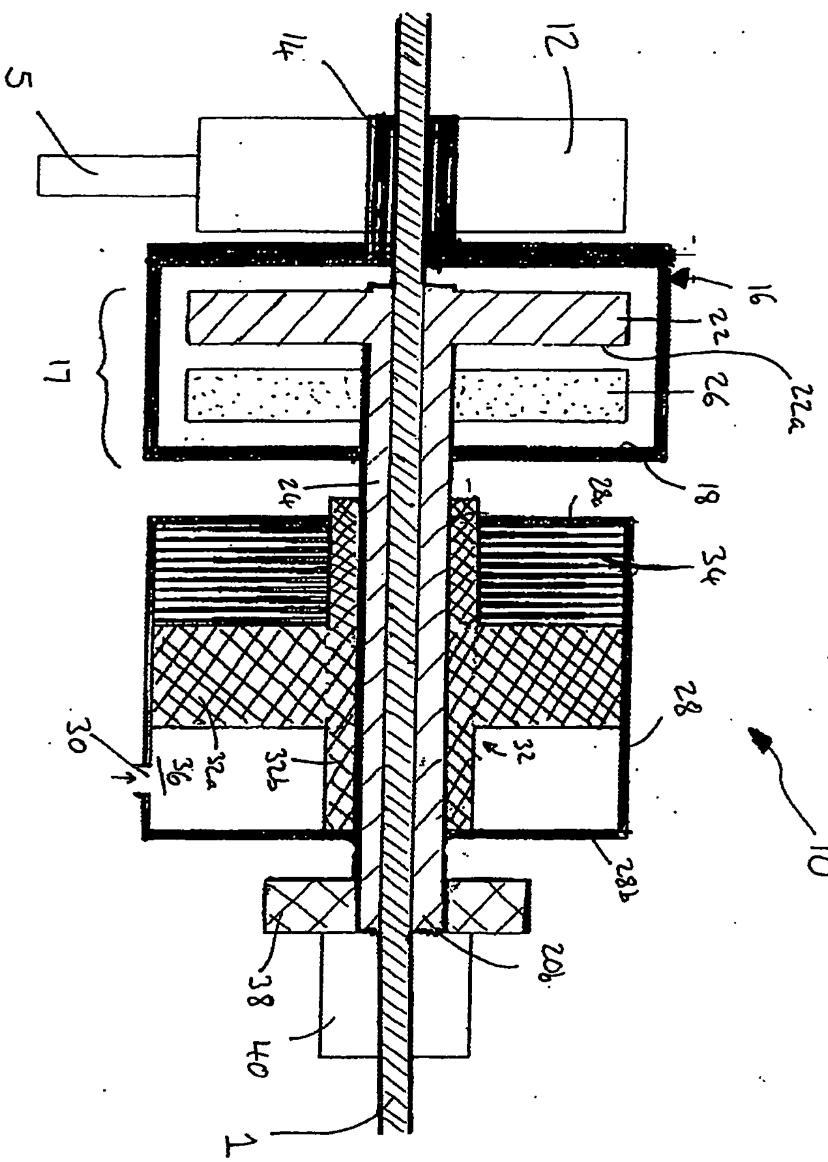
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Fig 2

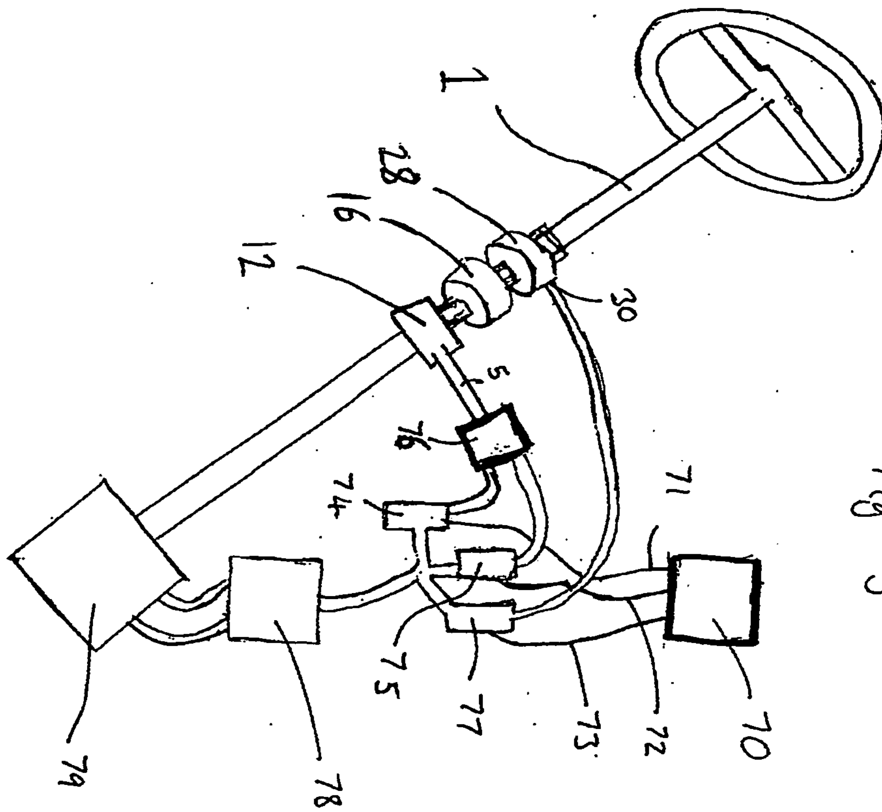

Fig 3